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Neutron Detection Efficiency Measurements of the Domino Detector for the NEMO Experiment

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Summer Fun



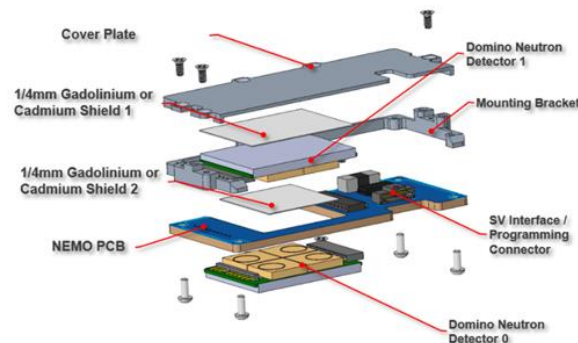
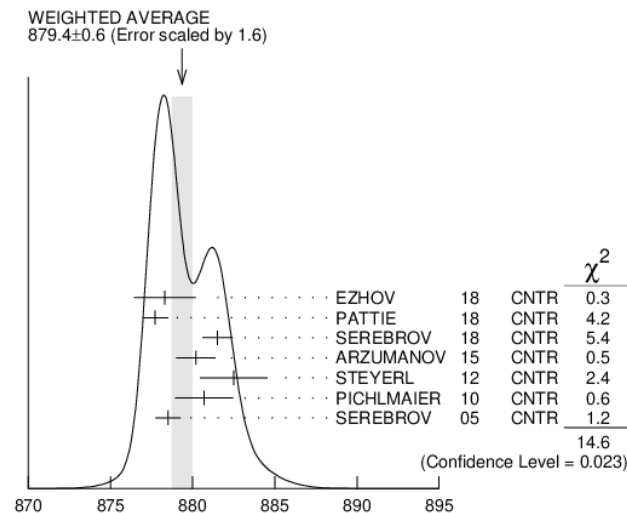
Christian Young (ISR-1)

- Educational Background
 - Purdue University, 2020
 - B.S. Nuclear Engineering
 - University of Tennessee, 2025?
 - Ph.D. Nuclear Engineering
- Intelligence and Space Research (ISR)
 - Space Science & Applications (ISR-1)
 - Dr. Kurtis Bartlett, Dr. Karl Smith
- Research
 - Neutron detector efficiencies for moon orbit mission
 - Work at UTK: Neutron detection and radiography



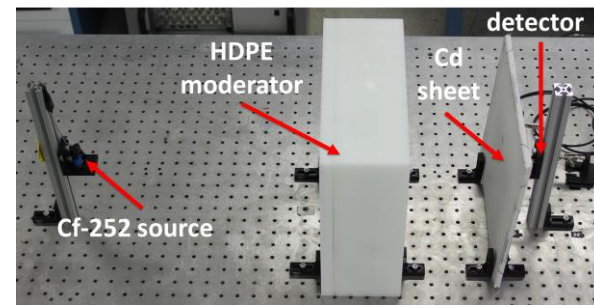
Research Overview and Motivation

- **Neutron lifetime measurements disagree**
 - Plot from the Particle Data Group
- **Differences stem from “beam” vs “bottle”**
- **New idea: space as a form of containment**
 - Thermal neutrons from moon’s surface
- **Neutron-lifetime Experiment in the Moon's Orbit**
 - CubeSat ride-along
 - Domino neutron detector on board
- **Need to validate the detector’s efficiency**
 - RDT data only based on MCNP simulations



Research Approach

- **Combined simulation and physical approach**
 - MCNP: Energy-dependent flux
 - Physical: True count rates
- **Take several measurements**
 - Variable moderator thicknesses
 - Cf-252 source
- **Iterative unfolding process to extract efficiencies**
 - Maximum-likelihood expectation-maximization
 - Monte Carlo methods for uncertainty



$$\begin{bmatrix} x_{1,1} & x_{1,2} & \cdots & x_{1,m} \\ x_{2,1} & \ddots & & \vdots \\ \vdots & & \ddots & \vdots \\ x_{n,1} & \cdots & \cdots & x_{n,m} \end{bmatrix} \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_m \end{bmatrix} = \begin{bmatrix} T_1 \\ T_2 \\ \vdots \\ T_n \end{bmatrix}$$

Summary of Results

- **Figure shows calculated neutron detection efficiencies up to 1 MeV**
- **Agreement with RDT efficiencies**
- **Improvements can be made**
 - Improved physical measurements
 - Reduced environmental impact
 - Longer count times
 - LANSCE
 - Time-of-flight measurements
 - Finer binning

